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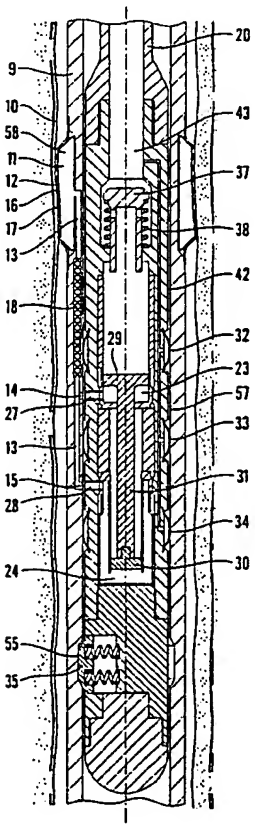
(54) Title: PACKER, SETTING TOOL FOR A PACKER AND METHOD FOR SETTING A PACKER



(57) Abstract: The invention relates to a packer (7) to be included in a production tubing (4) in a well bore (1). The packer (7) comprises an expandable bag (11) located on the outside (56) of a packer body (9), the bag (11) having an outwardly facing semi-permeable wall (12) made from fabric. When setting the packer, a liquid curable resin is injected into the bag (11), which causes an expansion of the bag (11). The resin partly penetrates the outwardly facing fabric wall (12) and seals against the well bore wall (10), and after curing forms a packer seal (58). The invention also relates to a setting tool for setting the packer (7) in the well bore (1) and a method for setting a packer (7) in a well bore (1).

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Packer, setting tool for a packer and method for setting a packer

The invention relates to a packer to be included in a production tubing in a well bore, for sealing against a wall of the well bore, wherein the packer comprises an essentially cylindrical packer body with connections for connecting to the production tubing.

The invention also relates to a setting tool for a packer, to be lowered into the packer by a drill string or coiled tubing when the packer forms part of the production tubing, for injecting two different resin components into resin inlet(s) of the packer body.

The invention further relates to a method for setting a packer comprising a body which forms part of a production tubing which is located in a well bore.

In recovery of hydrocarbons from hydrocarbon reservoirs, wells are drilled from the seabed or the surface of the earth, down to the reservoir. The wells are lined with pipes designated casing to prevent the well from collapsing. A production packer is placed in the lower end of the casing, above the reservoir, and a pipe designated production tubing is placed inside the casing, through the production packer, for conveying the hydrocarbon flow from the reservoir to the surface.

Some wells are drilled through more than one reservoir. In such wells the tubing normally extends to the lower reservoir. In order to control the inflowing from each reservoir, and sometimes also at different places in the same reservoir, inlet valves are included in the tubing at the desired locations. In order to obtain an effective use of the inlet valves, it is required to prevent hydrocarbons from flowing along the outside of the tubing, and therefore the space between the tubing and the well bore wall is either filled with concrete or sealed by a packer between each inlet valve. Such a packer is known as an "external casing packer". Whether the pipe in the reservoir area is designated casing or tubing is a matter of terminology, or the configuration of the well, and such a packer may thus as well be called an "external tubing packer". The tubing consist of sections which are screwed together, and each end of the packer has threads, in order to be screwed in between two tubing sections. The packers are set by expanding packing means of the packer, which is done by a setting tool which is lowered into the packer and connected to the packer for manipulating the packing means.

A known packer to be included in a production tubing in a well bore comprises a hollow rubber element, which is inflated by a curable fluid, e.g. a liquid resin or concrete, which is injected by the setting tool. After injection, the concrete or resin cures and keeps the rubber element in the inflated position, in which it seals

between the tubing and the well bore wall. This type of packer is encumbered with the drawback that the rubber element may be damaged during the installation or inflation. Further the temperature, pressure and well fluids adversely influence the integrity of the rubber, and therefor the lifetime of such a packer is often shorter than desired. This type of packer is therefore likely to leak.

In a production packer, and other packers intended for sealing between the inner tubing and the outer casing, the sealing is achieved by radially expandable mechanical packing means, which may be hydraulically activated by a setting tool. Here the above mentioned problems related to the inflatable rubber element do not exist. These packers, do, however, require that the outer contact surface, i.e. the inside of the casing, is circular. Although a well is drilled by a circular bit, the well bore wall is far less circular than the inside of the casing. Known packer designs which are intended for sealing between the tubing and the casing are therefore unsuitable to establish a proper seal between the tubing and the well bore wall.

US 4 057 118 A describes a packer comprising a body with radially packing means for sealing between the packer and the well bore wall, wherein the packer has rotatable connections between the body and the tubing.

US 6 006 836 describes a method for sealing a plug in a pipe disposed in a well bore. A hardenable epoxy sealing composition which hardens into a resilient solid mass is placed into the pipe adjacent the plug, and then allowed to harden.

The object of the invention is to provide a packer to be included in a production tubing in a well bore, for sealing against a wall of the well bore, a setting tool for the packer and a method for setting a packer comprising a body which forms part of a production tubing which is located in a well bore, in which the above discussed problems related to leakage are reduced or eliminated.

The objects are achieved according to the invention by a packer according to claim 1, a setting tool according to claim 13 and a method according to claim 18.

The invention thus relates to a packer to be included in a production tubing in a well bore, for sealing against a wall of the well bore, wherein the packer comprises an essentially cylindrical packer body with connections for connecting to the production tubing. The packer comprises an expandable bag located on the outside of the packer body, which bag has an outwardly facing semi-permeable wall made from fabric. The packer also comprises at least one injection conduit which connects the inside of the bag and one or more resin supplies. When setting the packer, a liquid curable resin having an injection pressure is injected from the resin supply or supplies, through the injection conduit(s) and into the bag (11), which

causes an expansion of the bag. The resin partly penetrates the outwardly facing semi-permeable fabric wall and seals against the well bore wall, and after curing the resin forms a packer seal.

In one embodiment the resin supplies are formed by one or more inlets on the inside of the packer body, and the injection of the liquid curable resin is done as an injection into the resin inlet(s). The injection into the resin inlet(s) may be done by a setting tool which carries two components of a liquid curable resin. The mixing of the two resin components may take place in the packer or in the setting tool.

In another embodiment the resin supplies are formed by two or more resin storage chambers attached to or integral with the packer body, for storing two components of a two component resin. In this embodiment the injection of the liquid curable resin is done as emptying the resin storage chambers into the resin conduit(s) and further into the bag. The emptying of the resin storage chambers may be done by pistons which force the resin out of the resin storage chambers. The pistons may be moved by means of a pressurised hydraulic control liquid which is supplied from a setting tool. In this embodiment the mixing of the two resin components will have to take place in the packer.

In still another embodiment the resin supplies may be formed by one or more resin storage chambers attached to or integral with the packer body, for storing one component of a two component resin, and inlets on the inside of the packer body. In this embodiment the injection of the liquid curable resin is done as emptying the one resin component from the resin storage chamber(s), and injecting the other resin component into the resin inlet(s). The emptying of the resin storage chamber(s) and the injection into the resin inlet(s) may be done as discussed above. Also in this embodiment the mixing of the two resin components will have to take place in the packer.

Preferably a deformable packer mesh is located on the outside of the bag, whereby the expansion of the bag deforms the mesh and forces the mesh against the well bore wall, whereupon the resin which penetrates the outwardly facing fabric wall fills openings of the mesh.

In order to control the injection of resin into the well bore, the permeability of the fabric is preferably dependent upon the differential pressure across the fabric, i.e. an increasing internal pressure in the bag is accompanied by an increasing penetration of resin through the bag.

The invention also relates to a setting tool for a packer according to the embodiment in which the resin supplies are formed by one or more inlets on the

inside of the packer body, and the injection of the liquid curable resin is done as an injection into the resin inlet(s). The setting tool comprises a connection for connecting to a drill string or coiled tubing, for supporting the setting tool and supply hydraulic control fluid from the drill string or coiled tubing. The setting tool will be lowered into the packer by the drill string or coiled tubing when the packer forms part of the production tubing, for injecting two different resin components into the resin inlet(s) of the packer body. The setting tool also comprises two resin chambers for storing two different components of a two-component resin, a resin channel extending from each resin chamber to a common or separate resin outlet(s) on the outside of the setting tool, one piston in each resin chamber and a piston rod which connects the pistons. The pistons and the piston rod are movable by the hydraulic control fluid, for a proportional ejection of the two resin components. Further the setting tool comprises a positioning device for positioning the resin outlet(s) of the setting tool relative to the resin inlet(s) of the packer body when the setting tool enters the packer. The setting tool also comprises radially expandable annular seals located on each side of the resin outlet(s), for sealing against the inside of the packer body, and thereby isolate the resin outlet(s) of the setting tool and the resin inlet(s) of the packer body.

The radial expansion of the annular seals may be provided by mechanical means, e.g. a plurality of conical segments which are forced in under the annular seals by a movement of the setting tool in the well bore.

In order to provide a setting tool which can be operated in a convenient way, it is, however, preferred that the annular seals are expandable by means of the hydraulic control fluid.

The setting tool preferably comprises a pressure sensitive control valve which prevents the hydraulic control fluid from moving the pistons and the piston rod until the pressure of the hydraulic control fluid exceeds an opening pressure. This opening pressure is lower than the pressure which is required to expand the radially expandable annular seals, and it is thereby ensured that the radially expandable annular seals isolate the resin outlet(s) and the resin inlet(s) before resin is injected from the setting tool into the packer.

The invention further relates to a method for setting a packer comprising a body which forms part of a production tubing which is located in a well bore. The method comprises injecting a liquid curable resin having an injection pressure in an expandable bag located between the packer body and a wall of the well bore; which bag has an outwardly facing semi-permeable wall made from fabric. The resin thereby fills and expands the bag and partly penetrates the fabric and seals against the well bore wall. Further the method comprises essentially maintaining

the injection pressure during curing of the resin, whereupon the resin after curing forms a packer seal.

When the bag is inflated, the bag displaces fluid which is present in the well, and keeps the resin in place during curing. The resin which penetrates the bag contacts the well bore wall and seals against the well bore wall, and thus the resin fills and seals the space between the tubing and the well bore wall. It is thereby provided a packer in which problems related to leakage are reduced or eliminated.

Further objects, preferred embodiments and advantages of the invention will appear from the detail part of the description.

The invention will now be explained in more detail in connection with a description of a specific embodiment, and with reference to the drawings, in which:

fig. 1 illustrates locations of packers according to the invention in a well bore,

fig. 2 illustrates a longitudinal section through a packer according to the invention,

fig. 3 illustrates a longitudinal section through a setting tool according to the invention,

fig. 4 illustrates the setting tool of fig. 3 inserted in the packer of fig. 2, prior to setting of the packer,

fig. 5 corresponds to fig. 4, after setting of the packer,

fig. 6 illustrates the packer of fig. 2 after setting,

fig. 7 is a side view of a packer mesh according to the invention, prior to the setting of the packer,

fig. 8 is a side view of the packer mesh of fig. 7, after the setting of the packer.

Fig. 1 illustrates locations of packers 7 according to the invention in a well bore 1. The well bore 1 has been drilled from a surface, above fig. 1, to drain various hydrocarbon reservoirs 2. A casing 5 has been lowered into the well bore, to prevent the well from collapsing. The casing 5 is terminated in a production packer 6 above the uppermost reservoir 2. A tubing 4 has been lowered into the casing 5, through the production packer 6, and further down to the reservoirs 2.

The reservoirs 2 are separated by non permeable strata 3, and in order to obtain an optimum draining of the reservoirs, it is required to control the inflowing from each reservoir 2. This control is achieved by inlet valves 8, which are integral parts

of the tubing 4. In order to obtain an effective use of the inlet valves 8, it is required to prevent hydrocarbons from flowing between the reservoirs 2 along the outside of the tubing 4, and the space between the tubing 4 and the well bore wall 10 is therefore sealed by a packer 7 between each inlet valve 8. Like the inlet valves 8, the packers 7 are integral parts of the tubing 4.

Fig. 2 illustrates a longitudinal section through a packer 7 according to the invention. The packer 7 is included in a production tubing 4, which has been lowered into a well bore 1, as discussed with reference to fig. 1. The packer 7 comprises an essentially cylindrical packer body 9, which is provided with not illustrated threaded connections of a standard, well-known design, by which it has been connected to not illustrated production tubing 4 (se fig. 1) above and below the packer 7. Centralizers of a known design are included as a part of the tubing 4 adjacent to the packer 7, for keeping the packer 7 essentially in the centre of the well bore 1. It is seen that the inside of the packer body 9 is empty, and thus hydrocarbons are free to flow through the packer 7.

The packer 7 comprises an expandable bag 11 located on the outside 56 of the packer body 9, which bag 11 has an outwardly facing semi-permeable wall 12 made from fabric. An inner wall 60 of the bag 11 faces the packer body 9, and may be attached to the packer body 9, e.g. by gluing or a tight fit. The inner wall 60 may be made of the same material as the outer wall 12, or the inner wall may be made from a different material.

The packer 7 also comprises an injection conduit 13 which connects the inside of the bag 11 and two resin inlets 14, 15 on the inside 57 of the packer body 9. Further a deformable packer mesh 16 is located on the outside of the bag 11. The packer will be discussed in more detail after a description of the setting tool and a discussion of the setting of the packer.

Fig. 3 illustrates a longitudinal section through a setting tool according to the invention. The setting tool is designed for injecting two different resin components of a two component liquid curable resin into the resin inlets 14, 15 of the packer body 9.

The setting tool comprises a connection 21 for connecting to a drill string or coiled tubing 20. In the illustrated embodiment the connection 21 is a male connection with threads 41, which is screwed into corresponding threads of a female connection 22 in the lower end of a coiled tubing 20. The purpose of the coiled tubing is to support the setting tool when it is lowered into the packer body 9, and supply hydraulic control fluid from the surface, i.e. from the outside of the well, to internals of the setting tool.

The setting tool comprises a first resin chamber 23 and a second resin chamber 24 for storing a first and a second component, respectively, of the two-component resin. The first resin chamber 23 is defined by a first cylinder 45 with an end portion 61, and a first piston 29 opposite the end portion 61. The second resin chamber 24 is defined by a second cylinder 46 with an end portion 62, and a second piston 30 opposite the end portion 62. The second resin chamber 24 further has an inner cylinder 63, which is located within and is integral with the second cylinder 46.

The first piston 29 is slideable supported inside the first cylinder 45, and the second piston 30 is slideable supported inside the inner cylinder 63. The pistons are thereby movable towards the end portions 61, 62. A piston rod 31 connects the pistons 29, 30, and when they move, the two pistons 29, 30 will therefore move the same distance.

A first resin channel 25 extends from the first resin chamber 23 to a first resin outlet 27 on the outside of the setting tool, and a second resin channel 26 extends from the second resin chamber 24 to a second resin outlet 28, also located on the outside of the setting tool. The second resin channel 26 is partly formed by an annular space between the inner cylinder 63 and the second cylinder 46. The two resin outlets 27, 28 are closed by first and second breakable seals 48, 49, respectively.

The setting tool further comprises a positioning device for positioning the resin outlets 27, 28 of the setting tool relative to the resin inlets 14, 15 of the packer body 9 when the setting tool enters the packer 7. This positioning device is formed by a radially movable dog 35 which is located in a recess 54 in a dog body 51, which by means of threads 50 is screwed into the setting tool body 39. A spring 36 biases the dog 35 into the position in fig. 3, in which the dog abuts against a shoulder 64 and projects on the outside of the dog body 51. A setting tool head 53 is attached to the dog body 51 by a threaded connection 52.

Further the setting tool comprises radially expandable annular seals 32, 33, 34 located on each side of the resin outlets 27, 28. A control fluid channel 42 extends from a control fluid inlet space 43, to the inside or underside of each annular seal 32, 33, 34. The annular seals are made from an elastomer and have the form of lips, which in side areas 65 are fixed and sealed to the body 39 of the packer body 9. A supply of hydraulic pressure to the inside of the annular seals 32, 33, 34 will therefor expand the seals in radial direction.

Fig. 4 illustrates the setting tool of fig. 3 inserted in the packer of fig. 2, prior to setting of the packer. The setting tool has been lowered down in the packer 7 by

the coiled tubing 20. During this lowering the dog 35 was forced into the recess 54 by the inside 57 of the packer body 9. When the dog 35 arrived at a positioning groove 55 in the packer body 9 (see fig. 2), the spring 36 caused the dog 35 to enter the positioning groove 55, and thereby position the setting tool relative to the packer 7. The setting tool and the packer is adapted to bring the resin outlets 27, 28 of the setting tool in correspondence with the resin inlets 14, 15 of the packer body 9 when the dog 35 is in the positioning groove 55.

After the positioning of the setting tool in the packer 7 follows the actual setting of the packer, which is the injection of the resin. In order to ensure a proper transfer of resin from the setting tool to the packer body 9, it is required first to isolate the resin outlets 27, 28 and the resin inlets 14, 15. In the illustrated setting tool this is achieved by a pressure sensitive control valve which prevents the hydraulic control fluid from moving the pistons 29, 30 and the piston rod 31 until the pressure of the hydraulic control fluid exceeds an opening pressure.

The pressure sensitive control valve comprises a valve body 37 which by means of a valve spring 38 is biased against a valve seat 59. When the pressure of the hydraulic control fluid in the inlet space 43 exceeds the opening pressure, the valve body 37 is forced away from the seat 59, and control fluid is allowed to pass between the valve body 37 and the seat 59, through an opening 40 in the valve body 37 and into a fluid space 44.

The radially expandable annular seals 32, 33, 34 can be expanded by a pressure which is below the opening pressure for the control valve, and thus the isolation of the resin outlets 27, 28 and the resin inlets 14, 15 prior to the injection of the resin is done by first supplying hydraulic control fluid of a pressure below the opening pressure from the coiled tubing 20 to the control fluid inlet space 43. The fluid pressure will be transferred through the control fluid channel 42 to the inside of the radially expandable annular seals 32, 33, 34. This causes a radial expansion of the seals 32, 33, 34 until they contact the inside 57 of the packer body 9 and isolate the resin outlets 27, 28 and the resin inlets 14, 15.

Then follows the injection of the resin, which is done by supplying hydraulic control fluid of a pressure above the opening pressure for the control valve. The valve body 37 then moves away from the seat 59, and the hydraulic control fluid flows to the fluid space 44. The fluid pressure in the fluid space 44 forces the first piston 29 down in the first cylinder 45, which causes a flow of the first resin component from the first resin chamber 23 to the first resin outlet 27, in which the first resin component is injected into the first resin inlet 14. The piston rod 31 transfers the movement of the first piston 29 to the second piston 30, which moves down in the second cylinder 46. This causes a flow of the second resin component

from the second resin chamber 24 to the second resin outlet 28, in which the second resin component is injected into the second resin inlet 15. As a part of the injection, the first and second breakable seals 48, 49 is broken by the pressure of the resin. Since the two pistons 29, 30 due to the piston rod 31 will move the same distance, the two resin components will be ejected proportionally from the two resin outlets 27, 28.

For a further understanding, reference is made to fig. 5, which corresponds to fig. 4, after setting of the packer.

From the resin inlets 14, 15 the two resin components flow through the injection conduit 13 and into the bag 11. In the illustrated embodiment, a static mixer 18 for mixing a two-component resin is located in the injection conduit 13. The injection conduit 13 is formed by a longitudinal channel in the packer body 9, and the static mixer 18 comprises a plurality of oblique surfaces 19, which ensure a proper mixing of the two liquid resin components.

The injection of the resin causes an expansion, i.e. an inflation, of the bag 11, as illustrated in fig. 5. The resin partly penetrates the outwardly facing fabric wall 12 and contacts and seals against the well bore wall 10, and thus the resin fills and seals the space between the packer body 9 and the well bore wall 10.

Then follows the curing of the resin. In order to maintain the inflation of the bag and ensure a good sealing effect, the resin injection pressure is preferably maintained during the curing of the resin. The injection pressure of the resin is controlled by the pressure of the control fluid, which is supplied from the surface, and thus the pressure of the control fluid is preferably maintained during the curing. After curing the resin forms a packer seal 58.

After the setting of the packer, the setting tool is lifted out from the packer 7, and the packer remains in the set condition, as illustrated in fig. 6.

As mentioned, the illustrated packer 7 comprises a deformable packer mesh 16 located on the outside of the bag 11. The expansion of the bag 11 deforms the mesh 16 and forces the mesh 16 against the well bore wall 10, whereupon the resin which penetrates the outwardly facing fabric wall 12 fills openings 17 in the mesh 16. The mesh 16 provides an armouring to the packer seal 58, and reinforces the packer seal. The mesh 16 also serves as a spacer and provides a distance between the bag 11 and the well bore wall 10, which allows the formation of a differential pressure across the fabric of the outwardly facing wall 12 during the inflation of the bag 11. This differential pressure facilitates the penetration of the resin through the fabric, and thus assists in the formation of a good packer seal 58. Finally, the

mesh 16 is protects the bag 11 when the tubing 4 with the packer 7 is lowered into the well bore 1, and thus this mesh 16 is very favourable.

Fig. 7 illustrates an embodiment of a packer mesh 16 in the condition it has before expansion of the bag 11. The packer mesh 16 is formed by a cylindrical tube or sleeve made from metal sheet, and is provided with regularly spaced longitudinal slits 17. The metal sheet is deformable and has a long elongation before fracture, and thus after the tube of fig. 7 has been expanded by the bag 11, it gets the shape of the mesh of fig. 8, in which the slits 17 have been widened out into openings 17.

In order to provide an even distribution of resin and a packer seal with an essentially uniform thickness, the bag 11 is preferably essentially annular, and extends around the packer body 9. The bag 11 can be glued to the packer body 9, or attached to the packer by a tight fit. In order to ensure that resin can freely flow into the bag 11, it is, however, preferred that the bag 11 in some way is positively attached to the packer body in the area of the inlet of the injection conduit 13.

In order to ensure a sealing effect between the bag 11 and the packer body 9, it is preferred that also the inner wall 60 of the bag or the complete bag is made of a semi-permeable fabric, causing the resin to penetrate through the fabric of the inside of the bag, and seal against the packer body 9.

The expandability of the bag from the position in fig. 2 to the expanded position in fig. 6 can be achieved by the bag 11 being foldable, and can assume a folded position in which the outwardly facing fabric wall 12 is proximal to the packer body 9 and an unfolded position in which the outwardly facing fabric wall 12 is proximal to the well bore wall 10. The expandability can, however, also be achieved by a bag which is made from an elastic or plastic fabric.

When setting the packer, which may be located several hundred metres, or even a couple of thousand metres below the surface, it is important to be able to control the formation of the packer seal 58. As discussed, this is partly done by the pressure sensitive control valve, which does not allow ejection of resin from the setting tool before the pressure is above an opening pressure. A further control of the resin injection is achieved by a bag in which the permeability of the fabric is dependent upon the differential pressure across the fabric. This feature can be achieved by a fabric which comprises elastic-plastic strands with a long elongation before fracture. An increasing differential pressure across the fabric thereby causes an elongation of the strands and expansion of pores in the fabric and thus an increasing permeability of the fabric. An increasing internal pressure from the resin in the bag 11 thereby provides an increasing penetration of resin through the fabric.

In another embodiment the fabric in addition to the elastic-plastic strands also includes stiff strands with a short elongation before fracture. The fabric is adapted in such a way that the stiff strands break when the bag 11 is subjected to an internal threshold pressure, which causes a sudden increase in the permeability of the fabric. It is thereby achieved a bag with a sudden increase in the permeability when the resin pressure exceeds the threshold pressure. The resin pressure is provided by the pressure of the hydraulic control fluid, which is controlled from the surface, and it is thereby provided a convenient way of controlling the formation of the resin packer seal.

Most fabrics have some sort of semi-permeability, and a number of fabrics can be used. The permeability can be modified by impregnation or surface treatment. A favourable fabric is made from yarn of PA 6.6 High Tenacity LDPF, density 470 dTex 136 filament (without twisting), with 21/21 strands per cm, binding 1/1, covered by a silicone layer of 25g /m2. This fabric is available from FOV Fabrics AB, Borås, Sweden.

A number of resins can be used. The curing process develops heat. In order to reduce the development of heat, which can be detrimental to the resin, a filler, which does not develop heat, may be included in the resin. The filler can be included in the two resin components. A favourable two-component resin is the "Araldite Casting Resin System", comprising "Araldite CY 5995", "Hardener HY 925" and "Filler Silica Flour", which is available from Vantico UK, Askim, Sweden.

After the setting of the packer, the setting tool will be contaminated by resin, and a cleaning is cumbersome and may be injurious to the operator's health. Therefore the cylinders 45, 46, 63 of the resin chambers 23, 24, the resin channels 25, 26, the pistons 29, 30 and the piston rod 31 are preferably disposable. Preferably the principal resin containing components, i.e. at least the cylinders 45, 46, 63 of the resin chambers 23, 24 and the pistons 29, 30 form part of a disposable cartridge. Such a cartridge may also include the spacer ring 47 for keeping the cylinders 45, 46 in place. The first and second resin channels 25, 26 with the resin outlets 27, 28 may be made from disposable pipe inserts. A removal of the contaminated parts would then include first removing the resin channels 25, 26, then unscrewing the dog body 51 from the setting tool body 39, and withdraw the cartridge from the inside of the setting tool.

The invention also relates to method for setting a packer 7 comprising a body 9 which forms part of a production tubing 4 which is located in a well bore 1. This method comprises

- injecting a liquid curable resin having an injection pressure in an

expandable bag 11 located between the packer body 9 and a wall 10 of the well bore 1, the bag 11 having an outwardly facing semi-permeable wall 12 made from fabric, the resin thereby fills and expands the bag 12 and partly penetrates the fabric and seals against the well bore wall 10,

- essentially maintaining the injection pressure during curing of the resin, whereupon the resin after curing forms a packer seal 58.

For an explanation and a more detailed description of the method according to the invention, reference is made to the above description.

The invention has in the above been described with reference to a specific embodiment. A number of variants are, however, possible, e.g. related to the shape and number of the injection conduit or conduits of the packer body, the resin channels of the setting tool, and the number and location of resin inlets and outlets of the packer body and the setting tool, respectively. A specific example of such a variant is to mix the two resin components in a static mixer in the setting tool, and then inject the mixture into the packer body through a single resin inlet.

PATENT CLAIMS

1. A packer (7) to be included in a production tubing (4) in a well bore (1), for sealing against a wall (10) of the well bore (1), wherein the packer (7) comprises an essentially cylindrical packer body (9) with connections for connecting to the production tubing (4), characterised by

- an expandable bag (11) located on the outside (56) of the packer body (9), the bag (11) having an outwardly facing semi-permeable wall (12) made from fabric,
- at least one injection conduit (13) connecting the inside of the bag (11) and one or more resin supplies, whereby an injection of a liquid curable resin having an injection pressure from the resin supplies, through the injection conduit(s) (13) and into the bag (11), causes an expansion of the bag (11), the resin partly penetrates the outwardly facing fabric wall (12) and seals against the well bore wall (10), and after curing forms a packer seal (58).

2. A packer (7) according to claim 1, characterised by that the resin supplies are formed by one ore more inlets (14, 15) on the inside (57) of the packer body (9), and that the injection of the liquid curable resin is done as an injection into the resin inlet(s) (14, 15).

3. A packer (7) according to claim 1, characterised by that the resin supplies are formed by two or more resin storage chambers attached to or integral with the packer body, for storing two components of a two component resin, and that the injection of the liquid curable resin is done as emptying the resin storage chambers through the resin conduit(s).

4. A packer (7) according to claim 1, characterised by that the resin supplies are formed by one or more resin storage chambers attached to or integral with the packer body, for storing one component of a two component resin, and inlets (14, 15) on the inside (57) of the packer body (9), and that the injection of the liquid curable resin is done as emptying the one resin component from the resin storage chamber(s), and injecting the other resin component into the resin inlet(s) (14, 15).

5. A packer (7) according to any of the preceding claims, characterised by a deformable packer mesh (16) located on the outside of the bag (11), whereby the expansion of the bag (11) deforms the mesh (16) and forces the mesh (16) against the well bore wall (10), whereupon the resin which penetrates the outwardly facing fabric wall (12) fills openings (17) in the mesh (16).

6. A packer (7) according to any of the preceding claims, characterised by that the bag (11) is essentially annular, and extends around the packer body (9).

7. A packer (7) according to any of the preceding claims, characterised by that the expandability of the bag (11) is achieved by the bag (11) being foldable and can assume a folded position in which the outwardly facing fabric wall (12) is proximal to the packer body (9) and an unfolded position in which the outwardly facing fabric wall (12) is proximal to the well bore wall (10).

8. A packer (7) according to any of the preceding claims, characterised by that the permeability of the fabric is dependent upon the differential pressure across the fabric.

9. A packer (7) according claim 8, characterised by that the fabric comprises elastic-plastic strands with a long elongation before fracture, an increasing differential pressure across the fabric thereby causes an elongation of the strands and expansion of pores in the fabric and thus an increasing permeability of the fabric, an increasing internal pressure from the resin in the bag (11) thereby provides an increasing penetration of resin through the fabric.

10. A packer (7) according to claim 9, characterised by that the fabric also includes stiff strands with a short elongation before fracture, the fabric is adapted in such a way that the stiff strands break when the bag (11) is subjected to an internal threshold pressure, causing a sudden increase in the permeability of the fabric.

11. A packer (7) according to any of the preceding claims, characterised by that a static mixer (18) for mixing a two-component resin is located in the injection conduit(s) (13).

12. A packer (7) according claim 11, characterised by that the injection conduit(s) (13) is/are formed by one or more longitudinal channels of the packer body, and the static mixer(s) (18) comprise(s) a plurality of oblique surfaces (19).

13. A setting tool for a packer according claim 1or 2 or any of the claims 5-12, to be lowered into the packer (7) by a drill string or coiled tubing (20) when the packer (7) forms part of the production tubing (4), for injecting two different resin components into the resin inlet(s) (14, 15) of the packer body (9), characterised by

- a connection (21) for connecting to the drill string or coiled tubing (20), for supporting the setting tool and supply of hydraulic control fluid from the drillstring or coiled tubing (20),
- two resin chambers (23, 24) for storing two different components of a two-component resin, a resin channel (25, 26) extending from each resin chamber (23,

24) to a common or separate resin outlet(s) (27, 28) on the outside of the setting tool, one piston (29, 30) in each resin chamber (23, 24) and a piston rod (31) which connects the pistons (29, 30), the pistons and the piston rod are movable by the hydraulic control fluid, for a proportional ejection of the two resin components,

- a positioning device (35, 36) for positioning the resin outlet(s) (27, 28) of the setting tool relative to the resin inlet(s) (14, 15) of the packer body (9) when the setting tool enters the packer (7),
- radially expandable annular seals (32, 33, 34) located on each side of the resin outlet(s) (27, 28).

14. A setting tool according to claim 13, characterised by that the radially expandable annular seals (32, 33, 34) are expandable by the hydraulic control fluid.

15. A setting tool according to claim 13 or 14, characterised by a pressure sensitive control valve (37, 38) which prevents the hydraulic control fluid from moving the pistons (29, 30) and the piston rod (31) until the pressure of the hydraulic control fluid exceeds an opening pressure.

16. A setting tool according to any of the claims claim 13 to 15, characterised by that the cylinders (45, 46, 63) of the resin chambers (23, 24), the resin channels (25, 26), the pistons (29, 30) and the piston rod (31) are disposable.

17. A setting tool according to any of the claims 13-16, characterised by that principal resin containing components (45, 46, 63, 29, 30) form part of a disposable cartridge.

18. A method for setting a packer (7) comprising a body (9) which forms part of a production tubing (4) which is located in a well bore (1), characterised by

- injecting a liquid curable resin having an injection pressure in an expandable bag (11) located between the packer body (9) and a wall (10) of the well bore (1), the bag (11) having an outwardly facing semi-permeable wall (12) made from fabric, the resin thereby fills and expands the bag (12) and partly penetrates the fabric and seals against the well bore wall (10),
- essentially maintaining the injection pressure during curing of the resin, whereupon the resin after curing forms a packer seal (58).

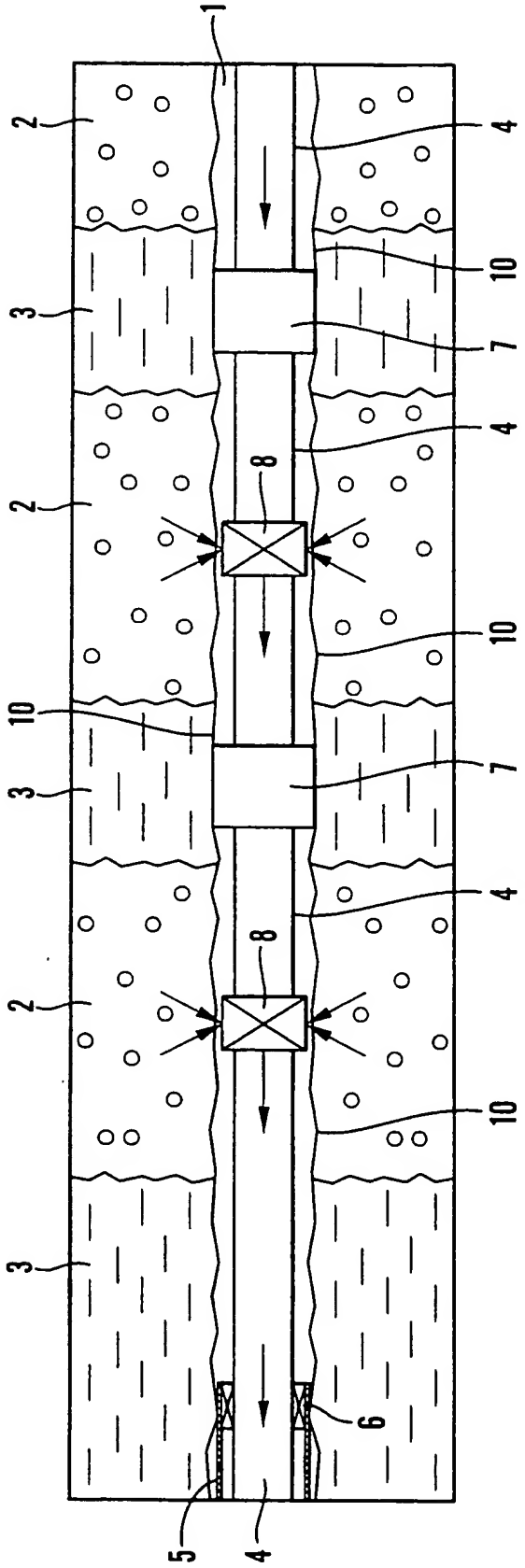

Fig.1

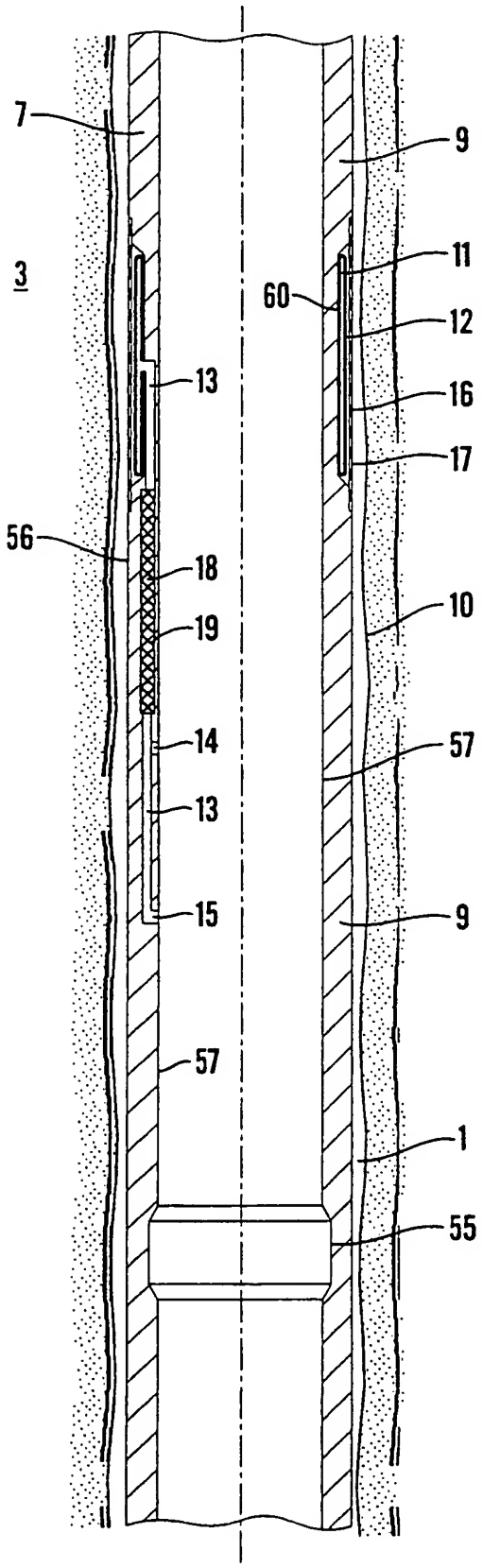

Fig.2

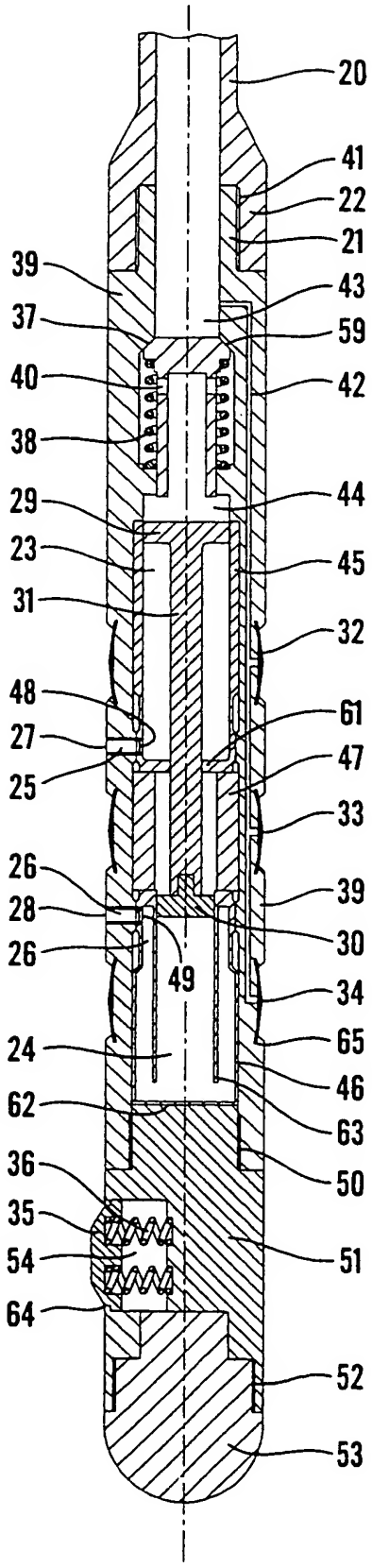
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Fig.3

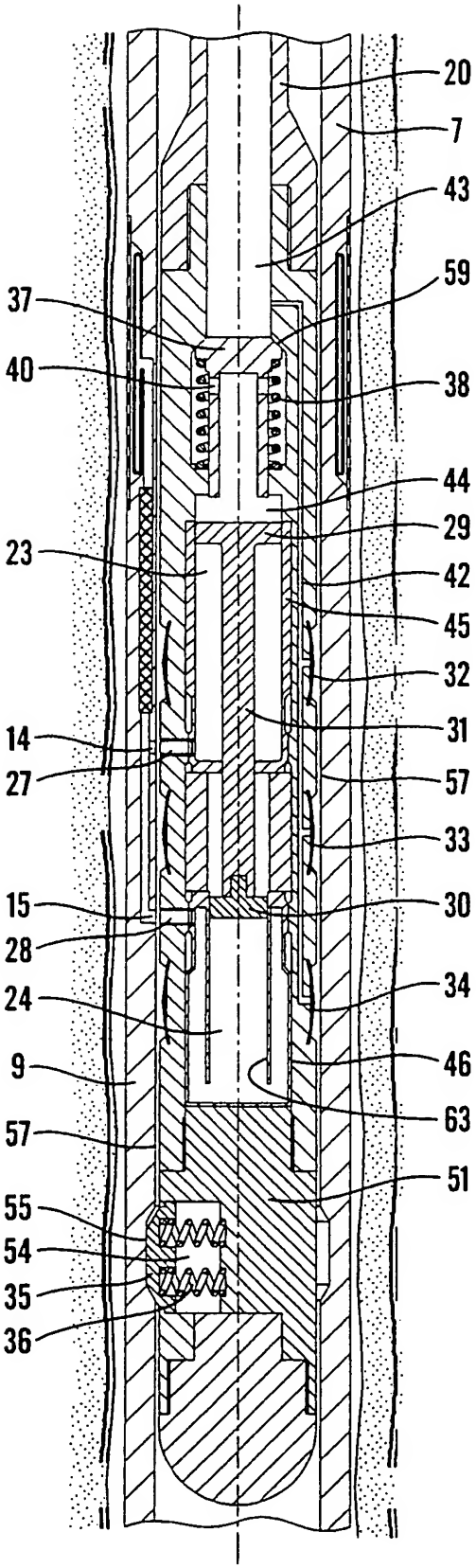

Fig.4

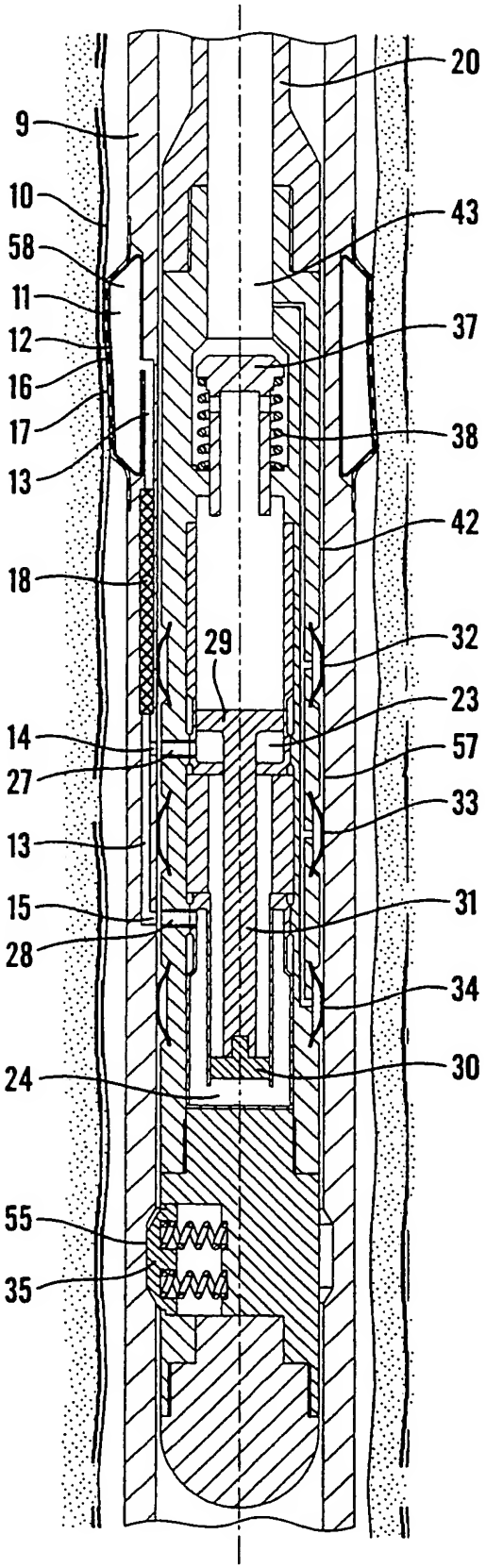
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Fig.5

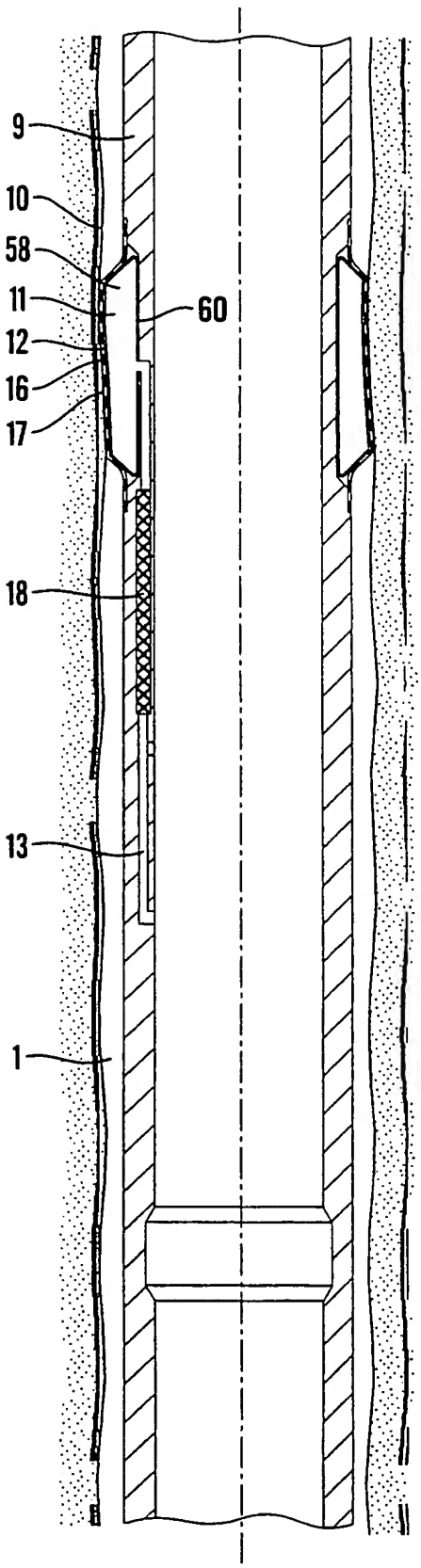

Fig.6

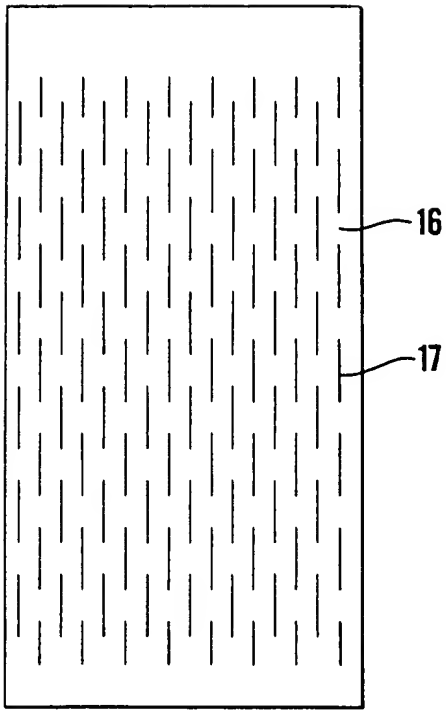

Fig.7

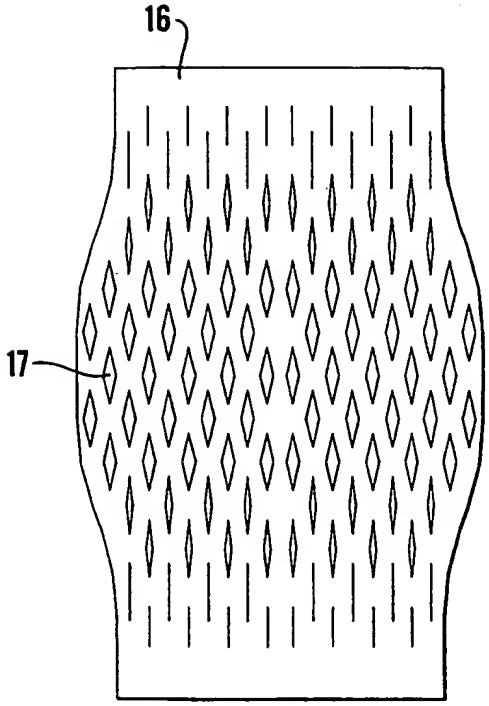

Fig.8

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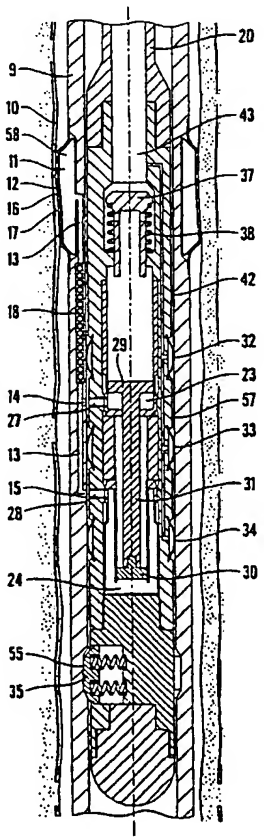
— *with international search report*

[Continued on next page]

(54) Title: PACKER, SETTING TOOL FOR A PACKER AND METHOD FOR SETTING A PACKER



(57) **Abstract:** The invention relates to a packer (7) to be included in a production tubing (4) in a well bore (1). The packer (7) comprises an expandable bag (11) located on the outside (56) of a packer body (9), the bag (11) having an outwardly facing semi-permeable wall (12) made from fabric. When setting the packer, a liquid curable resin is injected into the bag (11), which causes an expansion of the bag (11). The resin partly penetrates the outwardly facing fabric wall (12) and seals against the well bore wall (10), and after curing forms a packer seal (58). The invention also relates to a setting tool for setting the packer (7) in the well bore (1) and a method for setting a packer (7) in a well bore (1).

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INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3460624 A (J. AITKEN ET AL), 12 August 1969 (12.08.69), column 5, last paragraph; figure 5	1-4,6-8,18
A	US 2681706 A (N. POTTORF), 22 June 1954 (22.06.54)	1-18
A	US 5778982 A (E. HAUCK ET AL), 14 July 1998 (14.07.98)	1-18
A	US 6009951 A (M.P. CORONADO ET AL), 4 January 2000 (04.01.00)	1-18

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Information on patent family members

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PCT/NO 01/00175

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3460624 A	12/08/69	NONE	
US 2681706 A	22/06/54	NONE	
US 5778982 A	14/07/98	NONE	
US 6009951 A	04/01/00	NONE	